

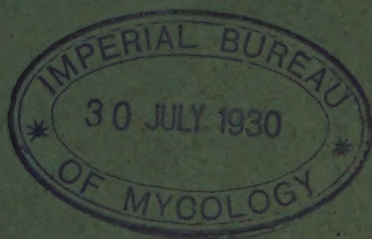
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THE JOURNAL OF THE ROYAL SOCIETY OF WESTERN
AUSTRALIA, VOL. XIV.

AN OUTLINE OF THE HISTORY OF PHYTOPATHOLOGY
With special reference to
ITS DEVELOPMENT IN AUSTRALIA,

BY
W. M. CARNE, F.L.S.

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PRESIDENTIAL ADDRESS

By

W. M. CARNE, Esq., F.L.S.

(Delivered on the 10th July, 1928; Published 17th October, 1928.)

INTRODUCTION.

Phytopathology, Plant Pathology, Vegetable Pathology, or, as it is known in Great Britain, Applied Mycology, is the study of plant diseases and their control. It is essentially an economic study and must be clearly distinguished from Mycology, the study of fungi.

The recognition of disease in plants dates back to the earliest records. For instance, in the Bible we find a number of references such as "If there be in the land famine; if there be pestilence, blasting, mildew, locust, or if there be caterpillar . . ." (Kings I., viii., 37.)

It must be understood that by "disease" we mean any condition of a plant which prevents the development, either in quality or quantity, of the growth which is possible and desired for such a plant. It must also be understood that diseases coming within this definition are in many cases of little consequence to the plant functions of life and reproduction, though of great consequence to the grower as a result of their effects on the plant products he aims at securing.

Diseases are of varied origin. They may arise from hereditary defects, from unsuitable growth conditions, from injury and from parasitism. Convenience, and the enormous field of Zoology, have lead to plant troubles caused by animals, particularly insects, being regarded as the field of the Economic Zoologist or Economic Entomologist. In its modern conception, therefore, Phytopathology deals with all diseases other than those of animal origin. It must be admitted that diseases of nematode origin are frequently regarded as in the sphere of Phytopathology, and that in other cases, more especially in the virus diseases, entomology and pathology overlap.

For the purpose of this address Whetzel's "An Outline of the History of Phytopathology" (15), the only book on the subject, has been freely utilised. With modifications and additions this author's classification of Eras and Periods has been adopted.

THE ANCIENT ERA.

(From the first records down to the end of the Fifth Century.)

Writers of this Era, which falls naturally into the Hebraic, Greek and Roman Periods, recognised the part played by environmental factors, such as frost and drought, in diseases causation. They recognised also the facts of susceptibility and of resistance to disease. Rusts of cereals in particular received attention, but while such philosophers as Theophrastus and Pliny noted the association of epidemics with seasonal and environmental conditions, in general, superstition prevailed. The farmer of the day besought his gods to protect his crops, and attributed disease to evil influences.

THE DARK ERA.

(From the fall of the Roman Empire until the beginning of the Seventeenth Century.)

During this long and unproductive period little was added to our knowledge of plant diseases. The one outstanding figure, according to Whetzel, was the Arabian writer, Ibn-el-Awam, who studied and described many diseases of grape vines and trees at Seville in Spain in the Tenth Century. The revival of learning in the Fourteenth and Fifteenth Centuries led to the study of the ancient Greek and Roman philosophers. The outlook of students was, however, one of slavish acceptance of authority and the observations and theories of Theophrastus and Pliny, in particular, as to plant diseases were blindly accepted.

AUTOGENETIC ERA.

(From the Seventeenth Century to the middle of the Nineteenth Century.)

(a) *The Renaissance Period.* (The Seventeenth Century.)

This period marked a revival of interest in the study of diseases, particularly by the more intelligent growers of plants. Methods, more or less successful, were devised for the control of diseases. In 1660 at Rouen in France, we hear of the first legislative enactment in regard to plant diseases. A decree ordered the destruction of barberry bushes on the ground that they were in some way associated with epidemics of wheat rust. The experimental proof of this observation had to wait until the middle of the Nineteenth Century when the fact that wheat rust (*Puccinia graminis*) required in Europe the barberry (*Berberis communis*) as an alternative host was demonstrated by the brilliant work of the Tulasne brothers in France.

No great contribution to our knowledge of the causes of disease was made in this period, and the ideas of students were still dominated by the philosophies and superstitions of the past.

(b) *The Zallingerian Period.* (Eighteenth Century.)

This period was marked by the co-existence of two points of view amongst writers on plant diseases—the philosophic and the practical. The influence of the revival of interest in biologic classification which, culminating in the Linnean System of nomenclature in 1753, laid the foundation of modern Taxonomy, strongly influenced philosophic writers. Zallinger in his "De morbis plantarum" classified diseases into five groups on symptomatic grounds. The theories of causation accepted by Zallinger and his contemporaries were largely those of the ancient philosophers. Fungi assoc-

iated with disease he regarded as the products, rather than the causes of diseases. On the practical side the period was marked by the production of books for the practical grower in which emphasis was laid on disease control rather than causes. Various more or less effective methods of treatment were put forward. Riedel in 1751 recommended *excision* for cankers of trees—still an accepted treatment—and *bleeding* to remove superfluous sap, an analogy with the medical ideas of the times which hardly accords with our ideas.

(c) *The Ungerian Period (1807-1853).*

Pathology in this period became a recognised field for scientists. The separate philosophic and practical points of view of the preceding period were united by Unger, in 1833, in his "Exantheme der Pflanzen." In the early half of the Nineteenth Century the foundations of Botany as a science were laid. Pathology appealed to the botanical physiologists of the day, and, as a consequence, Unger founded the School of Autogenetists. He considered that disease had its origin in internal disorganisation of the nutritive processes. Fungi associated with disease he recognised as distinct organisms, but regarded them as originating in the affected plants, the idea of spontaneous generation of life being a fundamental conception of the time.

At the close of the Autogenetic Era phytopathologic thought was primarily physiologic, the study of plant diseases had become distinctly scientific, and the cause of diseases was held to be autogenetic.

PATHOGENETIC ERA.

(1853 to about 1915.)

This era marks the foundation of Phytopathology as we know it to-day. The brilliant mycologic work of the Tulasne brothers on rusts, smuts, mildew, etc., and of De Bary, the founder of modern Mycology, on smuts, rusts and potato blight, proving the causative parasitism of fungi in these diseases; the passing of the conception of spontaneous generation, swept away by that great scientist and demonstrator, Pasteur; and the mental freedom from the dogma of the fixity of forms given to the scientific world by Darwin; proved the inspiration of a brilliant and productive period in Phytopathology. This inspiration, thriving on the fruits of its own production, has continued so that its effects in increasing strength are felt to-day. In spite of ups and downs caused by apparently insoluble problems and their brilliant solution, Phytopathology is to-day a young and vigorous branch of applied science, and still far from reaching the crest of its maturity. In this Pathogenetic Era biologic science became truly scientific being based upon accurate observation and experiment. It developed a healthy spirit of independence of thought in its followers prepared to accept nothing finally unless the truth could be demonstrated. The armchair philosophies of classic scholars gave way to theories based on data obtained in field and laboratory.

The historic and disastrous outbreak of Potato Blight (*Phytophthora infestans*) in Europe in 1844-45, as is often the case with the great disasters of history, was productive of good. It brought Phytopathology into world prominence and inspired the interest of the most noted scientists of the

day. It emphasised the part which parasitism played in plant disease and brought home in unmistakable fashion the relation of plant disease to national and world prosperity, and even to the movements of people.

As an instance of the latter near home, the spread of farming inland from the little pioneer settlement around Pt. Jackson in New South Wales had its stimulus largely in the rust which prevented the growth of wheat for flour near the coast. As another illustration, who can estimate the part played in the development of U.S.A. by the Irish Immigration which followed the historic epidemics of Potato Blight in Ireland in 1844 and following years?

The Kuhnian Period. (1853—1883).

This period was powerfully influenced by three great scientists, De Bary the mycologist, Liebig the chemist, and Pasteur the bacteriologist. Whetzel named it after Kuhn, the father of Phytopathology, whose book, "Die Krankheiten der Kulturgewächse" was published in 1858. Kuhn was a farm manager, an experimenter, a student and a lecturer in agricultural science. It was undoubtedly owing to the twofold (practical and theoretical) nature of his training that his was the first phytopathological work in which fungi were recognised as pathogenes. He recognised that disease might be due to physiologic causes on the one hand and to parasites on the other, though attributing to the former the greater importance. In this period we find Berkeley, the father of British Mycology, making England's first contributions to Phytopathology which were, however, addressed rather to growers than to scientists.

At the close of the Kuhnian Period phytopathologic thought was essentially mycologic though the physiologic side had not been entirely overlooked. The classification of diseases was etiologic, and the autogenetic idea of the origin of diseases associated with fungi had largely given way to the pathogenetic viewpoint. Pasteur, De Bary, Kuhn and others had demonstrated beyond doubt that parasites could, and did, cause disease.

The Pre-Modern Period. (1883 to about 1915).

Phytopathology now became recognised as a definite branch of applied science. Great advances were made in control measures. The application of bacteriological technique to laboratory methods led to greater knowledge of parasitism and widened the range as well as the number of plant parasites. Millardet, in France, developed an accidental discovery and produced Bordeaux Mixture which is still one of the best and most widely used fungicides. Burill in U.S.A. in 1878-1884 and Wakker in Holland in 1883-1889 first demonstrated that among the bacteria were pathogenes of plants.

In 1885 Phytopathology received its first official recognition by the formation of a section of Mycology in the Botanical Division of the United States Department of Agriculture. Two years later the title was changed to Section of Vegetable Pathology, a more suitable name for an applied science based by no means entirely on Mycology. The lead given by the United States was followed all over the world as it came to be recognised that the provision of phytopathological services was an essential function

of government. It naturally followed that pathologists appointed by Governments have been attached to departments of agriculture, horticulture and forestry, or experiment stations. Also arising out of the realisation of the important part played by disease in plant life, it was realised that educational institutions giving courses in agricultural and related studies must include Phytopathology as an essential subject. In some countries and especially in U.S.A. and Canada it came to be ranked as a major subject, and the first Chair of Phytopathology was founded at Cornell University in 1907.

The first official recognition in the Empire dates from 1890 when D. McAlpine and Dr. N. A. Cobb were appointed Plant Pathologists to the Department of Agriculture in Victoria and New South Wales respectively.

During this period two schools of pathologic thought existed. One, the Predispositionists, were the successors of Kuhn. The greatest exponent of this school was Sorauer. His attitude was that, while admitting that parasites played a definite part in disease causation, parasitic diseases were more the result of environmental conditions which affected the plants, directly or indirectly predisposing them to the attacks of parasites. His work "*Handbuch der Pflanzenkrankheiten*," published in 1874-1886 laid great emphasis upon the diseases of non-parasitic origin. In its present fourth (and revised) edition, it still forms the standard work on such diseases. Marshall Ward, the greatest English pathologist up to recent times, was also a predispositionist in outlook. His studies in parasitism are said to have laid the foundations of all later investigations into the nature of susceptibility and immunity in plants. The other school, the Pathogenetists, predominated the Pre-Modern Period and found many distinguished followers. Hartig, the founder of forest pathology, Frank, Kirchner, Klebahn and Brefeld in Germany, Rostrup in Denmark, Eriksson in Sweden, Woronin in Russia, Bos in Holland, Prilleux and Delacroix in France, McAlpine in Australia, Scribner, Galloway, Erwin-Smith, Burrill, L. R. Jones, Arthur and others in America were outstanding figures. The leadership in Phytopathology, which had had its origin in Germany, passed to North America. There the enthusiasm of a younger group of scientific investigators, free from the dogmas and prejudices of tradition, found wide scope in an almost virgin field. In this Pathogenic School, the mycologic outlook was predominant. Many of its workers were mycologists rather than pathologists. The textbooks of the period, with the exception of a few by predispositionists, such as Sorauer's *Handbuch*, dealt essentially with parasitic diseases, and little attention was paid to either the non-parasitic diseases or to the relation of environmental factors to infection by parasites. Great advances were made in the determination of causes of parasitic diseases and in the classification of the pathogenes. Improvement in disease control resulted from new or improved fungicides, notably lime-sulphur solutions and finely divided sulphur dusts. A new line of attack on disease brought Phytopathology into contact with Genetics. The breeding of disease resistant plants, the most promising method of fighting diseases, has and is giving excellent results. This flourishing line of work had its origin in the pioneer labours of W. A. Orton of U.S.A., and Farrer in Australia.

Writers on phytopathological subjects found means for publication in various botanical, agricultural and other scientific serials. In 1911, Phytopathology, the first journal dealing only with pathological subjects, com-

menced publication as the official organ of the American Phytopathological Society. This Society was founded in 1909 and was the first of its kind.

The Pre-Modern Period marks the passing of legislation in various countries to control infectious diseases within their areas and to prevent the introduction of new diseases from other countries. It is not the place here to discuss the value of governmental regulations in controlling disease. Undoubtedly they are essential though not ideal. Quarantine has obvious defects, and is unfortunately a tempting means of interfering with trade competition between States and countries. Undoubtedly its effectiveness is largely aided by natural barriers such as oceans and wide stretches of arid lands, such as separate the agricultural areas of Western Australia from the rest of the world.

An essential feature of the recognition of phytopathology in agriculture, etc., has been the development of means to educate growers in the knowledge of the most effective known methods of disease control. A high standard of farming or horticulture undoubtedly is more effective in controlling disease than governmental regulations.

MODERN ERA.

(About 1915 to present time.)

This era marks, in my opinion, the passing of the Pathogenetist and Predispositionist Schools. The modern attitude is wider and more scientific. Disease is recognised as being due to disturbances of—

- (a) Genetic origin. The results of undesirable mutations or of undesirable recombination of Mendelian factors. In this group may be classed self-sterility and hereditary dwarfings, chloroses, and malformations.
- (b) Physiogenic origin. The result of undesirable reactions between plants and environmental factors. This constitutes the large group of diseases of non-parasitic origin.
- (c) Parasitic origin. In these it is recognised that three groups of factors are concerned: the host, the parasite and the environment. For effective disease causation all three must be conjointly favourable. If all are at or near the optimum for disease causation, an epidemic or epiphytotic results. It is recognised that the environment acts not only on the parasite but also on the host, that it may aid the one and predispose the other. Thus it is that the school which regarded the predisposing effects of environment as the dominant factor in disease and that which looked upon the parasite as the outstandingly important factor, find their views merged into one.

The year 1915 has been tentatively chosen as marking the beginning of the Modern Era because in that year Edgerton experimentally demonstrated the relation of air temperatures to certain apple diseases. That parasitic diseases were related to certain environmental factors such as moisture and temperature, had been recognised as far back as the Ancient Era. Definite proof had been lacking, and, except in the Predispositionist School, little attention had been paid to this point except to record more or less casual observations. The classical work of the new viewpoint originated at Wisconsin University under L. R. Jones and his colleagues. Their attitude may be stated as "Explanation of the occurrence and severity of a parasitic

disease requires not only the recognition of the parasitic or 'casual factor,' but also the definition of the 'conditioning factors' of environment," and "the associated abnormal conditions which we term 'disease' are the resultants of the interaction of a plastic host and a plastic parasite under the play of variable environment" (6). This viewpoint appears to the writer to be the basis of the modern outlook on Pathology. It has involved not only a change in the outlook of the pathologist, but also in the training of future pathologists. It is obvious that mycology is not to be the dominating study of the future pathologist. Genetics, Bio-chemistry, Physiology and especially the physiology of parasitism, are equally essential. For the translation of knowledge of diseases into the practical application of control measures on farms and orchards, etc., some more or less detailed knowledge of agriculture, horticulture, forestry, etc., are required. Such an intellectual equipment in these rapidly expanding branches of science is becoming beyond the capacity of individuals. Specialised branches of Pathology and the use of team work on pathological problems has become inevitable. Already we have Physiologic Pathologists and Mycologic Pathologists. Team work has already been productive of excellent results and gives great promise for the future.

In the Modern Era we find Pathology passing through a remarkably vigorous and productive phase. Undoubtedly this is largely due to a recognition that increase in crop production may be obtained by three methods—

- (1) Improvement of cultural methods.
- (2) Breeding of plants more suitable for specific conditions.
- (3) Reduction of losses from disease and insect pests.

The success of the first two depends largely upon the third—the effective control of losses due to disease, etc. Hence the present recognition of the importance of Phytopathology.

The outstanding features of the Modern Era appear to be as follows:—

1. The recognition of the intimate association of the host, parasite and environment in parasitic diseases, and consequently of the importance of Physiology as well as Mycology in Phytopathology. The classic work at Wisconsin, U.S.A. (6) on the part played by soil temperatures and humidity in the development of soil-borne diseases of plants did much to bring home to pathologists the need of studying environment in relation to parasitic diseases.

2. The revival of interest in Physiogenic diseases, particularly, as a result of the great development of long distance transport of vegetable products, in those diseases peculiar to fruit in store. Work on these diseases has brought into further prominence the essential importance of Physiology and Bio-chemistry in Phytopathology. An outstanding result of the interest in this class of disease was the foundation, in 1921, of the Low Temperature Research Station at Cambridge, England. This station, working under the Food Investigation Board of the Department of Scientific and Industrial Research, has already done excellent work particularly in regard to Brown Heart of Australian apples exported overseas, a disease which, in 1922, caused a loss of approximately £250,000. The demonstration of this disease as a respiratory one readily prevented by control of the atmosphere of refrigerated holds is a brilliant illustration of the value of Physiogenic Pathology and also of team work (2).

The field of Physiogenic diseases is large and almost untouched from the experimental point of view. Of special importance to Australia are those affecting fruit shipments overseas, particularly Bitter Pit, Internal Breakdown, Scald and Soft Scald of apples. The two former, according to reports on the 1927 season, constitute the principal causes of wastage of Australian apples in Europe. Work on Bitter Pit, carried on under the writer's direction in this State during the present year, has demonstrated conclusively that Bitter Pit is a disease developed in apples in consequence of premature picking. A simple method of determining the maturity of apples has been devised which offers great promise as an aid to picking. The results of this investigation have not yet been published.

The work done at Rothamsted, England (1) and elsewhere, in regard to the essential presence in the soil in minute quantity, at least for some plants, of available boron, manganese and other elements not generally regarded as essential plant nutrients, has already proved valuable in Australia. Grey Speck, a disease of wheat and oats in Europe recently recognised in this State and South Australia, has been shown in the latter State to be due to a deficiency in the soil of available manganese (11).

3. The discovery of Biogenic Forms of Rust Fungi by Stakman and his associates at Minnesota, U.S.A., and in other groups by these and other workers. This discovery has revolutionised the work of breeding rust and other disease-resisting plants, and accounts at least in part for the limited results in this direction obtained by plant breeders in the past.

4. The recognition of plant breeding as the most effective method of disease control. The breeding of disease-resistant plants started by Orton in America, and Farrer (12) in Australia, has produced excellent results and promises to give even greater results in the future. The production of cabbages resistant to Cabbage Yellows in America, of bunt resistant wheats like Florence, and of flag-smut resistant wheats like Nabawa, in Australia, are illustrations of the results to be obtained. The production of early maturing wheats in our State, thus reducing the disorders due to moisture deficiencies in districts with a short growing season, has extended and promises still more in the future to extend the limits of our wheat belt. This phase links Phytopathology very definitely with Genetics, and further emphasises the intimate relation of Phytopathology with agricultural development.

5. The recognition of the importance of Virus diseases. The cause of these diseases is still unknown, though the fact that the juice of tobacco plants with mosaic will convey the disease to other plants was shown by Ivanovski as early as 1892. Allard in 1914 demonstrated that the same disease may be transmitted by aphids. Since then Virus diseases have received intensive study. Indeed it is probable that more investigations have been made in recent years in this group of diseases than in any other. Virus diseases have been shown to occur in most, if not all, of our crop plants and in some crops such as potato, tomato and banana they may constitute in Australia the most important factors limiting production. As Virus diseases are normally conveyed from affected to healthy plants by insects, mainly sucking insects, this group of diseases has brought Pathology into close touch with Economic Entomology.

6. The introduction of copper dust fungicides for seed treatment, following Darnell-Smith's demonstration in New South Wales of the value of copper carbonate dust for seed treatment of wheat as a preventative of

bunt; the introduction, as fungicides, of organic mercuric compounds such as Uspulun, Semesan and many others; the adoption of dusts, mainly with copper sulphate, copper carbonate or sulphur as the active ingredients, as substitutes for liquid fungicides for use in crops, particularly fruit trees; these represent the most recent development in disease control with fungicides.

7. In 1921 the Imperial Bureau of Mycology, an institution supported by the governments of the British Empire, was founded. It serves to link together the pathologists of the Empire and, like its sister bureau, the Imperial Bureau of Entomology, has been markedly successful. In 1922 it commenced to issue the Review of Applied Mycology, the first purely phytopathological abstracting journal. This has become recognised as a model of its kind and is of greatest value to pathologists throughout the world.

Many other phases of recent development in Phytopathological work could be mentioned. The foregoing, however, appear to the writer to especially indicate the trend of phytopathologic thought and to mark the principal points of recent development.

PHYTOPATHOLOGY IN AUSTRALIA.

Before closing this address I propose to give a short outline of the development of Phytopathology in Australia. We appear to have passed through two stages and to be on the threshold of a third. In the first stage, belonging to the Pre-Modern Era, the phytopathological workers of Australia were men from abroad, without specific training in Pathology, but who by their keen interest and natural ability helped to develop the study and lay the foundations of modern Pathology. These were succeeded in quite recent years by students of the Modern Era trained in Australia. These men received a training in scientific agriculture, including Pathology, and in many cases had had more specific training in Pathology abroad, particularly in America. Phytopathological work being regarded as a State function and the staffs being limited, investigational work had not only been subordinated to a large extent to routine identification of diseases and the promulgation of known methods of control, but had also been carried out without any more than a casual and unofficial co-operation between the workers in different States.

With the appointment in 1927 of Dr. B. T. Dickson, a Canadian Phytopathologist, as Chief, Division of Economic Botany, under the Commonwealth Council for Scientific and Industrial Research, which was established in 1926, a new period appears to be commencing. In the development, by the Council for Scientific and Industrial Research, of central laboratories for fundamental research, the appointment of a staff of research workers free from routine and advisory duties, co-operation with State workers and the allocation and co-ordination of research throughout the Commonwealth, there lies great opportunity for a marked speeding up in Phytopathology. Already this latest development has stimulated co-operation between workers, has reduced overlapping investigations in a country where the workers are so few, and by direct aid to State investigations with money, equipment and men has given most promising results. There is at present a feeling of optimism and enthusiasm amongst pathologists due, in this State at least, to a recognition that the period of isolation so marked in the past is passing for all time. The absence of col-

leagues of similar interests with whom to consult, the defects of libraries and equipment, the ignorance of the work going on with other States, and the feeling of geographical and mental isolation are passing. To the Imperial Bureau of Mycology, which links the pathologists of the Empire and to the Council for Scientific and Industrial Research and particularly to Dr. Dickson, as its pathological adviser, we owe this change. We know that we can refer our difficulties in identification and in literary references to the Imperial Bureau with certainty of receiving all the assistance it is able to give. Our local problems and difficulties we can refer to the C.S.I.R., knowing that so far as the problems justify it will co-operate with the State in any way which promises results.

In May, 1890, Daniel McAlpine was appointed Plant Pathologist to the Department of Agriculture in Victoria. This was the first appointment of the kind in the Empire and was closely followed in August of the same year by the appointment of Dr. N. A. Cobb to a similar position in New South Wales.

McAlpine, the father of Phytopathology in Australia, became, with Marshall Ward of England, one of the two greatest workers in this field in the Empire. Born in Scotland in 1849 he came to Australia in 1884 as lecturer in biology in Ormond College, Victoria. Appointed in 1890 as Plant Pathologist, he held that position until 1911 when he retired to take up a special investigation into Bitter Pit of apples under the Commonwealth Government. In 1915 he retired. Seventy four years of age and still taking an interest in the subject to which he contributed so much, the grand old man of Phytopathology in Australia rests on his laurels in retirement. Of his numerous publications, his monographs on the rusts and smuts of Australia are classics. These, with his monograph in five volumes on Bitter Pit, a systematic classification of the fungi of Australia, monographs on the diseases of potatoes and stone fruits, and many less important works, made him well known amongst phytopathological workers throughout the world. In Australia he became recognised as the greatest authority on pathological matters and to all intents and purposes he became unofficially the Plant Pathologist of Australia. He built up what is still the finest phytopathological library and herbarium in Australia. Essentially a pathogenetist, McAlpine belonged to pre-Modern times. Our outlook and technique have changed, our field has widened, our opportunities in education and equipment are greater, but still to the old man in Victoria we must render homage, not only as the pioneer in Australia but as one of the great world pioneers of modern pathology. May we never cease to accord recognition to the pioneers in all branches of Science who, like McAlpine, laid the foundations upon which we build to-day.

Cobb was more a predispositionist than McAlpine and interested himself in problems such as the resistance of wheat to rust rather than to those of purely mycologic interest. It was he who named that important export disease of apples, Bitter Pit. On the taxonomic side, Cobb, unlike McAlpine who described and named many species of fungi, was more interested in nematodes. This eventually became his chief interest and he is to-day Senior Nematologist to the U.S.A. Department of Agriculture. Cobb resigned in 1905.

C. C. Brittlebank who had been McAlpine's assistant, succeeded him in 1911. Brittlebank came from England. His assistants are products of

the Melbourne University. Their appointment and the recent provision of up-to-date laboratory equipment marks the beginning of the change over from the first to the second period in Australian Phytopathology.

Cobb in New South Wales was succeeded by Dr. Harvey Johnson, and the latter by Dr. Darnell-Smith. In 1927, Dr. R. J. Noble, a graduate of Sydney University succeeded Dr. Darnell-Smith, again marking the change over to locally trained men.

The position of Melbourne as the centre of phytopathological work in Australia, a status which was gained in McAlpine's day, has gradually passed to Sydney. This has been largely a result of the courses in Pathology and Genetics in the Agricultural School of Sydney University under the stimulating and inspiring influence of W. L. Waterhouse. Waterhouse, a Sydney graduate, with agricultural experience and post graduate training in England and America, is turning out young pathologists who have already made a distinct impression on the work in Australia. Though the outstanding teacher in phytopathology in Australia, Waterhouse is essentially an investigator and is carrying on, under Australian conditions, the work of Stakman and his colleagues in America on rusts and smuts of cereals. He was appointed Lecturer in Plant Pathology at Sydney University in 1921, the first full-time position of its kind in Australia.

At present every State has workers in pathology attached to Departments of Agriculture, or similar Government Departments except in South Australia, where the Pathologist is attached to the Waite Agricultural Research Institute.

The staffs at present are as under:—

New South Wales.—Biologist and six assistants in phytopathology.

Victoria.—Biologist, Plant Pathologist and two assistants.

Queensland.—Three Pathologists (including two on diseases of sugar cane).

South Australia.—One Pathologist.

Western Australia.—Economic Botanist and Plant Pathologist and one assistant in phytopathology.

Tasmania.—One Microbiologist.

In nearly every case these workers are trained in Australia. As must be obvious from the size of the staffs given above, except possibly in New South Wales, where the staff has increased considerably in recent years, research has had to be largely subordinated to routine work. Nevertheless, and particularly in recent years, our pathologists have helped to maintain the status of Australia earned by McAlpine and other early workers. It is difficult to single out the more important contributions, but the following appear to be particularly worthy of note:—

1. The introduction of copper carbonate dust for cereal seed treatment by Darnell-Smith (4).
2. Waterhouse's contributions to our knowledge of our rusts and smuts, their biogenic strains and the breeding of resistant varieties (13-14).
3. Nobles work on *Urocystis graminis* (8).
4. Hamblin's and Hyne's work on *Helminthosporium* spp. on wheat (5).

5. North's work on diseases of sugar cane (9).
6. Magee's determination of the cause of Bunchy Top of Bananas (7).
7. Pittman's work on Spotted Wilt of Tomatoes (10).
8. Samuel and Piper's work on Grey Speck of Oats in South Australia (11).
9. Carne's work on *Phytophthora hibernalis* (13).

The Commonwealth first came into the field of Phytopathology in 1911, when McAlpine was appointed for four years to investigate the cause and control of Bitter Pit in apples. Unfortunately this investigation was not very fruitful of results. In 1924 the Commonwealth Institute of Science and Industry, in co-operation with the Departments of Agriculture in New South Wales and Queensland, initiated investigations into the cause of Bunchy Top of Bananas. This disease, which was reported in Australia for the first time in 1913, is one of the most outstanding in the rapidity with which it practically wiped out an industry over a large area in New South Wales and Queensland. In the former State banana planting reached its maximum in 1922. By 1927, 90 per cent. of the area in the Tweed and Brunswick districts had gone out of production. The production in 1922 in Northern New South Wales was 460,000 cases. By 1925 this had fallen to 140,000. In the Currumbin district, in Queensland, the yield of 102,000 cases fell to 2,500 in 1925, and only five men were making a living where approximately 200 had previously found employment. Investigations by C. J. P. Magee, a Sydney graduate, demonstrated that Bunchy Top was a virus disease of the "potato leaf-roll" type conveyed by the banana aphid (7).

In 1926 the Commonwealth Council for Scientific and Industrial Research co-operated with the Waite Institute in investigating the Spotted Wilt disease of Tomatoes, by far the most important disease of this crop in Australia. The Council provided funds for an insect-proof glass house, and also the services of a pathological assistant. The latter, H. A. Pittman, in 1927 demonstrated that Spotted Wilt is a virus disease and found that it was conveyed by the common leaf thrips (*Thrips tabaci*) from affected to healthy plants (10).

At present the Council is co-operating with the State workers in the investigation of diseases in several States, and in this State it has this year provided the services of an assistant in connection with an investigation of Bitter Pit out under my direction.

CONCLUSION.

In conclusion, it is evident that Pathology at the present time is receiving more attention and more support throughout the world than at any time in its history. There is little doubt that it will return many fold the interest, enthusiasm, and funds which have and will be given to it. Pathology in Australia is vigorous and healthy, and with the helpful stimulus now coming from both Commonwealth and State Governments, promises to be even more productive of good. Science knows no boundaries. Diseases ignore States. The healthy spirit pervading Phytopathology in Australia, as elsewhere throughout the world, insures greater economy of effort, a more rapid solution of problems, and ultimately an increased agricultural production in Australia, provided that Commonwealth and States continue to work together on the present basis of helpful co-operation.

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